11.4

THE SEVERE WEATHER DATA INVENTORY (SWDI): SPATIAL QUERY TOOLS, WEB SERVICES AND DATA PORTALS AT NOAA'S NATIONAL CLIMATIC DATA CENTER (NCDC)

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ABSTRACT

NOAA's National Climatic Data Center (NCDC) archives Weather Surveillance Radar, 1988 Doppler (WSR-88D) data from the national network of ~160 NWS, DOD and FAA sites. These are commonly referred to as Next-Generation Doppler Radars (NEXRAD). The NCDC NEXRAD Archive contains over 1000 terabytes of volume scan data, known as Level-II, and derived products, known as Level-III. Several of the products in the NEXRAD Level-III data stream are point features describing general storm structure, hail, mesocyclone and tornado signatures. The NCDC developed software package, Java NEXRAD Tools, is used to decode these features into an Oracle Spatial geo-spatial database [1; 6]. The Warning Decision Support System – Integrated Information (WDSS-II) is used to generate storm cell, mesocyclone and tornado signatures from Level-II data using independent algorithms developed at the National Severe Storms Laboratory (NSSL) [3; 4]. The WDSS-II generated features are loaded into the geo-spatial database along with lightning data from the Vaisala's National Lightning Detection Network (NLDN) and observations from the NCDC Storm Events database [2; 8]. The Severe Weather Data Inventory (SWDI) provides user access to the geodatabase via the NCDC web page, Web Feature Services (WFS), SOAP or OPeNDAP [5; 7; 9]. The results of interactive web page queries may be saved in a variety of formats, including plain text, XML (GML), Well-Known Text, NetCDF and Shapefile [Appendix A].

1. INTRODUCTION

Severe weather impacts the lives of millions of people each year. The protection, planning, and response to these challenges are central to NOAA's mission. Part of this mission includes disaster planning, mitigation, and recovery which is often atop public perception and occupies many of NOAA's resources. Tools to aid in this mission are important for many reasons. Better preparedness and improved recovery can help save lives, reduce costs, and provide comfort. The development of NEXRAD Radar systems have dramatically improved severe weather detection and have saved countless lives. Algorithms developed at the National Weather Service (NWS) and the National Severe Storms Laboratory (NSSL) use NEXRAD data to detect and track tornados, hail and mesocyclones in real-time. While these data are invaluable for real-time operations, historical analysis is also beneficial. Comparison with other independent data sources such as human observations and lightning sensors provides a long-term source of quality assurance. The observational data tends to show biased information because reports are often located in populated places or along major roads. The remotely sensed data allows for a more homogenously spaced distribution of weather information.

2. DATA

The four initial data sources for the SWDI are the NEXRAD Level-III NWS-derived products, the NEXRAD WDSS-II severe weather output, the National Lightning Detection Network (NLDN) and the Storm Events database. The NEXRAD Level-III data are products generated with NWS algorithms from NEXRAD Level-II (base) volume scan data. Several of the Level-III products identify and describe severe weather. These products consist of mesocyclone, hail, tornado and storm structure point features which are decoded and geo-located using the Java NEXRAD Tools software package [1] (Figure 1).

The counterpart of the Level-III data is the output from the NSSL's Warning Decision Support System – Integrated Information (WDSS-II) software package [3; 4]. The WDSS-II runs independent algorithms from the NSSL on the NEXRAD Level-II data to derive mesocyclone, hail, tornado and storm structure features. The temporal resolution of both NEXRAD derived datasets is dependant on the scan mode of the Radar site and varies between 4 and 10 minutes. The entire NCDC archive of NEXRAD data will eventually be reprocessed to populate the SWDI. This includes general coverage of the continental United States since 1995 with the earliest data from 1991.

The NLDN (NOAAPORT stream) data are generated from Vaisala's national network of lightning sensors. The sensors use time-of-arrival and magnetic direction finding to identify and geo-locate each lightning event [2] (Figure 2). The temporal resolution of NLDN data is one second.

The Storm Events database consists of qualitative observations of events such as hail, tornados, lightning, flooding, high wind and more. The data either have a geographic coordinate specified or are organized by county or city. The Storm Events data are event

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summaries and contain data from 1950 to the present [8] (Figure 3).

3. GEO-SPATIAL DATABASE

An Oracle relational database with the Oracle Spatial extension is used to store the severe weather features. The database spatially links the diverse datasets together in a way that is not possible using conventional databases or data storage methods [6]. Having the severe weather data in a central geo-spatial database links the data to other NCDC datasets that are spatially registered in the database. The severe weather data can then be spatially joined to other datasets and vice versa. For example, the county, climate division, closest in situ sites, cities, schools and roads can easily be calculated for any spatially registered tornado signature. The simple, modular design allows datasets to remain unique and independent while sharing only a spatial relationship (Figure 4). A geographic location is all that is needed to add new datasets to the SWDI. This offers a high level of flexibility in dealing with many different types of data from various sources.

4. ACCESS

Several access methods are provided to accommodate various types of users. Dynamic web pages provide numerous interactive search options. Data may be downloaded in common formats such as plain text, XML (GML), Well-Known Text, NetCDF and Shapefile [Appendix A]. Users are able to search on several criteria including location, city, county, state, climate division, time period and product. To limit results, users may search specific attributes such as hail size, wind speed, etc (Figures 5, 6).

Web services provide automated access to the data via several established protocols. OPeNDAP, Web Feature Services (WFS) and SOAP provide numerous options for the direct integration of the SWDI into user applications such as ESRI ArcGIS, IDL, GrADS and MATLAB [5; 7; 9].

5. CONCLUSION

The SWDI provides efficient and user-friendly access to an extensive archive of severe weather data. The SWDI will aid in the quality control of severe weather products, facilitate new research and assist disaster response and mitigation. The relational geo-spatial database provides a modular, flexible solution for data storage and management. This allows SWDI datasets such as NEXRAD, NLDN and observational Storm Events to remain independent while sharing a common spatial relationship. Multiple data access methods are provided to satisfy different types of users. Interactive web pages provide extensive search options while web services offer an efficient method of automated data access. By incorporating web services, users may seamlessly integrate the SWDI into custom applications. The SWDI presents valuable severe weather data in a simple, flexible manner that benefits many user communities and exemplifies the overall NOAA mission.

6. REFERENCES

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2. Cummins, K. L., M. J. Murphy, E. A. Bardo, W. L. Hiscox, R. B. Pyle, and A. E. Pifer, 1998. A Combined TOA/MDF Technology Upgrade of the U. S. National Lightning Detection Network, J. Geophys. Res., 103, 9035-9044. Idone, V. P.,

3. Hondl, K.: 2002, Current and planned activities for the warning decision support system-integrated information (WDSS-II). *21st Conference on Severe Local Storms*, Amer. Meteo. Soc., San Antonio, TX.

4. Lakshmanan, V 2002, An extensible, multi-source meteorological algorithm development interface. *21st Conference on Severe Local Storms*, Amer. Meteo. Soc., San Antonio, TX.

5. OPeNDAP Website: http://www.opendap.org/

6. Oracle Spatial Website: http://www.oracle.com/technology/products/spatial/index.html

7. SOAP Reference Website: http://www.xml.org/xml/resources_focus_soap.shtml

8. Storm Events Website: http://www4.ncdc.noaa.gov/cgi-win/wwcgi.dll?wwEvent~Storms

9. WFS Reference Website: http://en.wikipedia.org/wiki/Web_Feature_Server

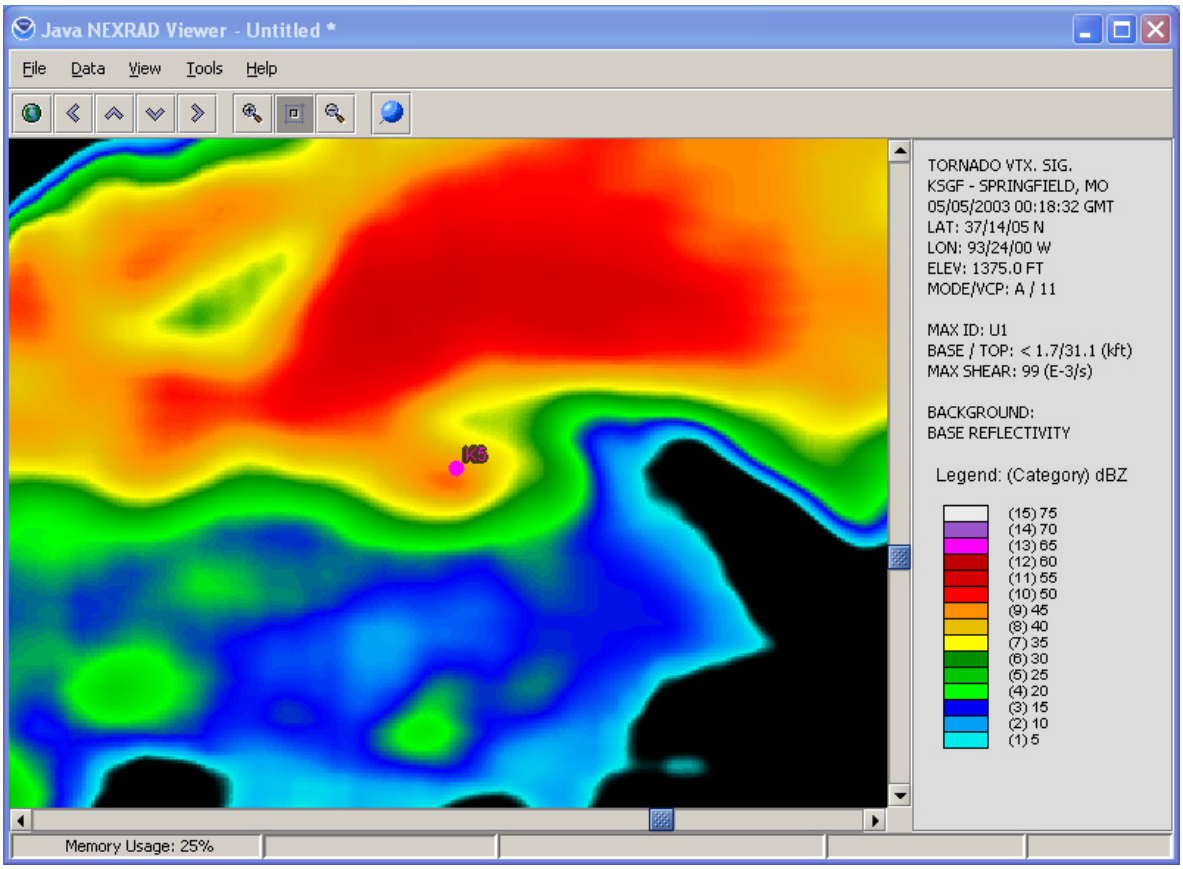


Figure 1. NEXRAD Level-III Tornado Vortex Signature and Reflectivity Data

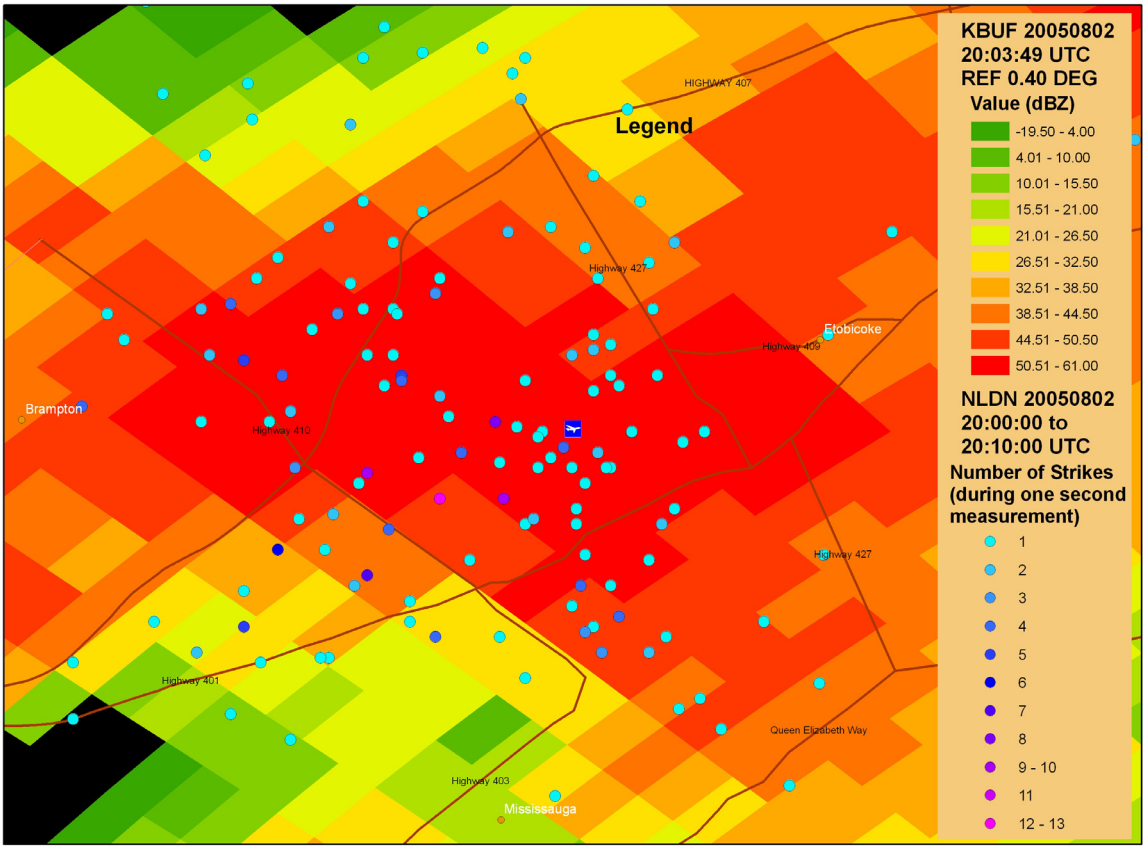


Figure 2. NLDN and NEXRAD Reflectivity Data

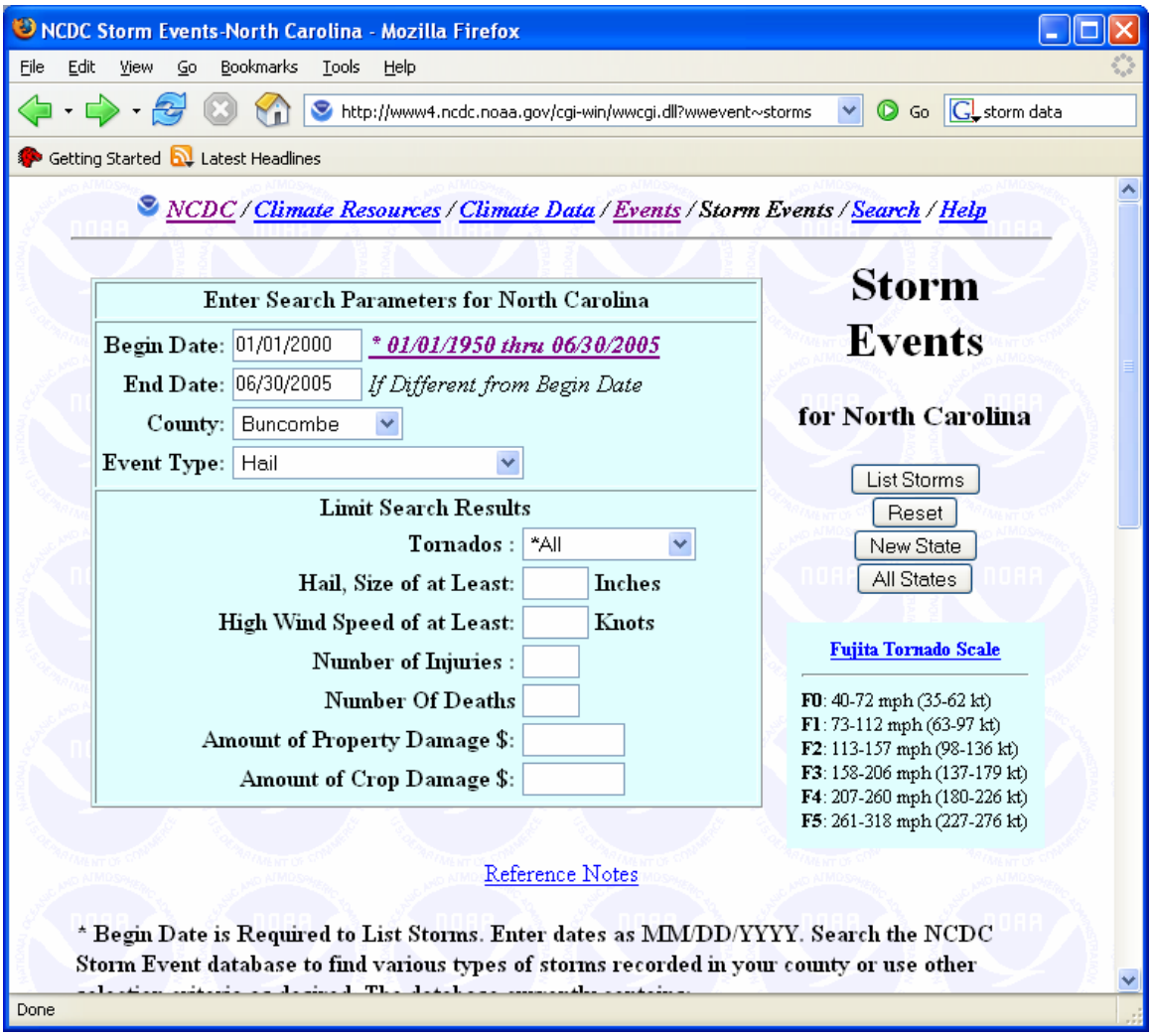


Figure 3. Storm Events Database

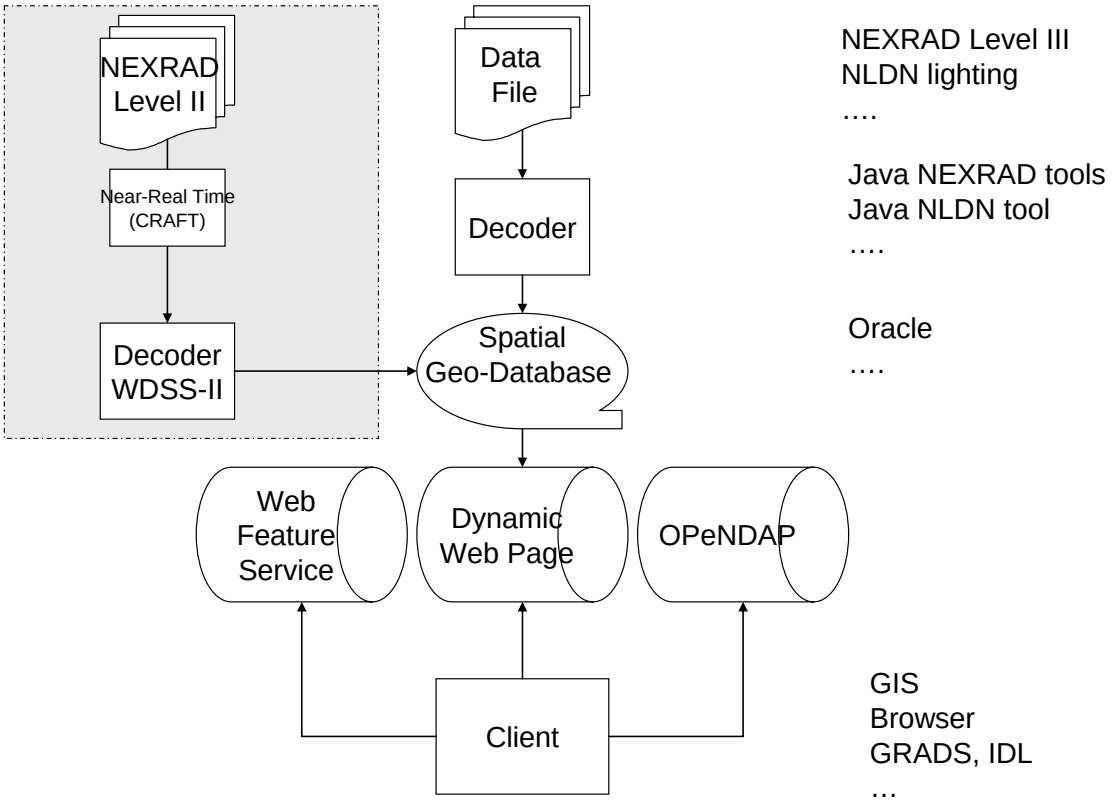


Figure 4. Severe Weather Data Inventory Flowchart

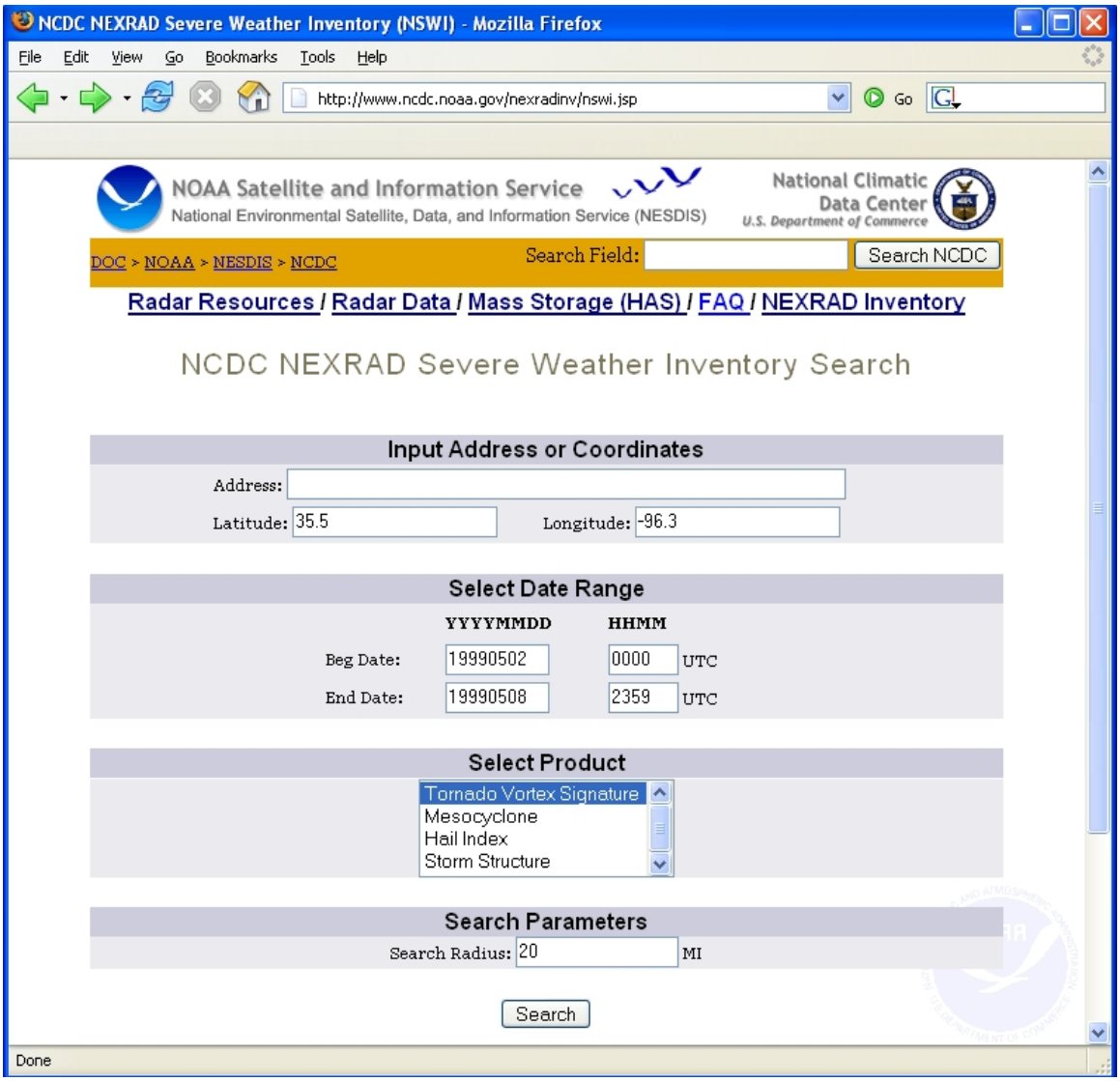
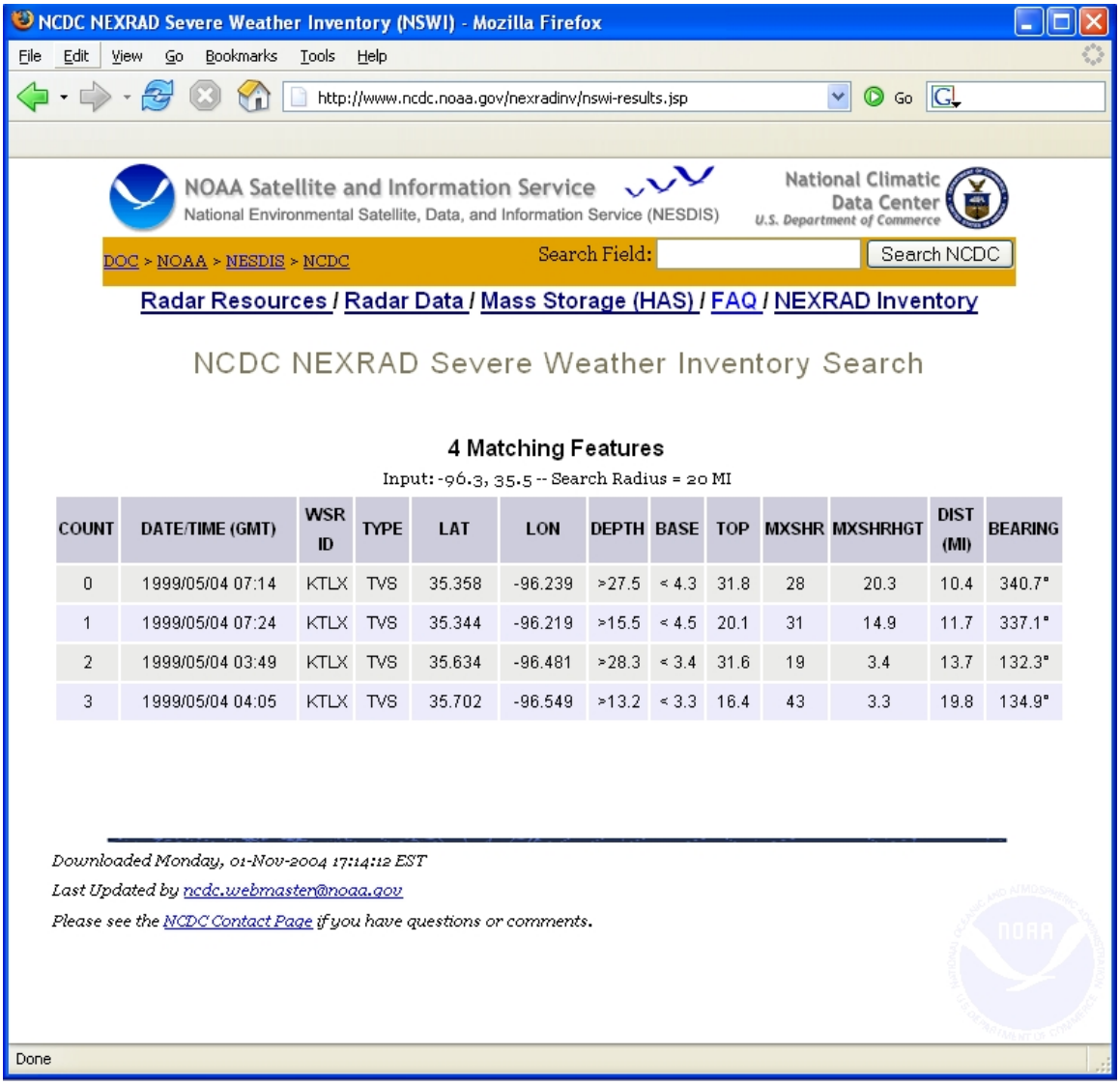


Figure 5. Severe Weather Data Inventory Interactive Web Page Access



COUNT	DATE/TIME (GMT)	WSR ID	TYPE	LAT	LON	DEPTH	BASE	TOP	MXSHR	MXSHRHGT	DIST (MI)	BEARING
0	1999/05/04 07:14	KTLX	TVS	35.358	-96.239	>27.5	< 4.3	31.8	28	20.3	10.4	340.7°
1	1999/05/04 07:24	KTLX	TVS	35.344	-96.219	>15.5	< 4.5	20.1	31	14.9	11.7	337.1°
2	1999/05/04 03:49	KTLX	TVS	35.634	-96.481	>28.3	< 3.4	31.6	19	3.4	13.7	132.3°
3	1999/05/04 04:05	KTLX	TVS	35.702	-96.549	>13.2	< 3.3	16.4	43	3.3	19.8	134.9°

Figure 6. Severe Weather Data Inventory Interactive Web Page Search Results

APPENDIX A

1. ESRI Shapefile [1]: "A shapefile stores nontopological geometry and attribute information for the spatial features in a data set. The geometry for a feature is stored as a shape comprising a set of vector coordinates." For more information: http://www.esri.com

2. Geography Markup Language (GML): "Geography Markup Language is an XML grammar written in XML Schema for the modeling, transport, and storage of geographic information." For more information: http://www.opengis.net/gml/

3. Well-Known Text (WKT): An ASCII text representation of geometry data. Defined in the OpenGIS Consortium "Simple Features for SQL" specification. For more information: http://dev.mysql.com/doc/mysql/en/GIS_WKT_format.html or http://publib.boulder.ibm.com/infocenter/db2help/index.jsp?topic=/com.ibm.db2.udb.doc/opt/rsbp4120.htm

4. NetCDF (network Common Data Form): “NetCDF (network Common Data Form) is an interface for array-oriented data access and a freely-distributed collection of software libraries for C, Fortran, C++, Java, and perl that provide implementations of the interface. The netCDF software was developed by Glenn Davis, Russ Rew, Steve Emmerson, John Caron, and Harvey Davies at the Unidata Program Center in Boulder, Colorado, and augmented by contributions from other netCDF users. The netCDF libraries define a machine-independent format for representing scientific data. Together, the interface, libraries, and format support the creation, access, and sharing of scientific data.” For more information: http://my.unidata.ucar.edu/content/software/netcdf/index.html